Perforation of the Graphene Layers via High Temperature Acidic Treatment of Graphite Oxide

Tur V.A., Fedorovskaya E.O., Bulusheva L.G., Okotrub A.V.

Nikolaev Institute of Inorganic Chemistry SB RAS, Novosibirsk, Russia
slawatur@mail.ru

Currently graphene-based materials are attracting an increasing attention in various applications, e.g. as electrodes in supercapacitors, due to its high electrical conductivity and chemical stability. Of particular interest is the structure with a large number of vacancy defects in the carbon layers, because these defects can help electrolyte ions to diffuse between the layers which can lead to improving of electrochemical performance of material. At the same time the carbon atoms on the edges of defects accumulate charge more efficiently than the atoms on the basal plane. These factors can lead to a substantial increasing of electrode specific capacity. Another factor that can be very important is the functionalization of the carbon layers. The presence of functional groups can improve the interaction of electrode surface with electrolyte and, in addition, be involved in redox processes which in turn lead to an additional pseudocapacity appearance.

In this work the method of obtaining of material which has a large number of vacancy defects in graphene layers (called perforated graphite – PG) and can be exfoliated with the formation of perforated graphene was proposed. This method involves heat treatment of graphite oxide in concentrated mineral acids, such as sulfuric, phosphoric acid or the mixture of these acids [1]. The effect of treatment time and temperature, as well as the acid choice on the structure, functional composition and electrochemical properties of the final product was also investigated [2]. It was found that the “quantitative” functional composition of the obtained samples depends strongly on the treatment parameters and can be controlled by adjusting the relevant temperatures and processing times, as well as the proportion of acids in a mixture. Study of the electrochemical properties of the carbon material showed that the capacity of an electrode made of the perforated graphite may reach values of 140 F/g. Such a high capacity can be explained by the presence of vacancy defects in the structure of perforated graphite, as well as the contribution of redox processes. Based on the obtained data the mechanism of the vacancy defects formation was proposed with using the methods of quantum chemistry and computer modeling.

[1] A.V. Okotrub, N.F. Yudanov, V.A. Tur et al., Physica Status Solidi B., **12 (**2012)., pp. 2620-2624.
[2] V.A. Tur, A.V. Okotrub, M.M. Shmakov et al., Physica Status Solidi B., **12 (**2013)., pp. 27470-2752.

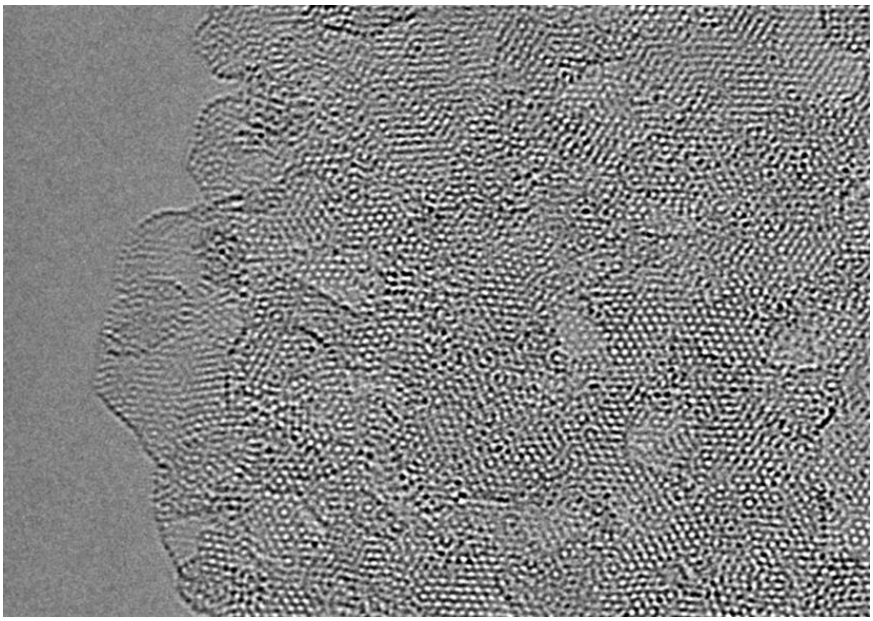

Fig 1. High resolution (2 nm) TEM image of the perforated graphite sample.